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Abstract: Areas of known mineralization in Ordovician through Devonian rocks on eastern Cornwallis Island were visited as reconnaissance for a project that will address the genesis and geological controls on Zn-Pb mineralization within the Polaris zinc district and elsewhere in the Arctic Islands. Parts of the Thumb Mountain, Cape Phillips, Allen Bay, Barlow Inlet, and Disappointment Bay formations are host to Mississippi Valley-type mineralization, which is variously localized by 1) normal faults, 2) facies boundaries, or 3) a major unconformity. Much of the mineralization is indicated by development of gossans, but some is present without any significant weathering features. The presence of showings that completely lack galena and have only sparse Fe-sulphides suggests that there may be more than one mineralizing event or fluid source behind the various showing types in the area.

Résumé : Dans la partie orientale de l'île Cornwallis, des secteurs de minéralisation connue dans des roches de l'Ordovicien au Dévonien ont été l'objet d'un levé de reconnaissance, dans le cadre d'un projet portant sur la genèse et les contrôles géologiques de la minéralisation en Zn-Pb au sein du district zincifère de Polaris et dans d'autres régions de l'archipel Arctique. Certaines parties des formations de Thumb Mountain, de Cape Phillips, d'Allen Bay, de Barlow Inlet et de Disappointment Bay renferment une minéralisation de type Mississippi-Valley, que 1) des failles normales, 2) des limites de faciès ou 3) une discordance majeure permettent de localiser. Une bonne partie de la minéralisation est signalée par la présence de chapeaux de fer, alors que certaines parties ne montrent aucune caractéristique d'altération d'importance. La présence d'indices entièrement dépourvus de galène et ne renfermant que de rares sulfures de fer permet de supposer que les divers types d'indices observés dans la région ont peut-être été le siège de plusieurs épisodes de minéralisation ou que les fluides qui y ont circulé provenaient de plusieurs sources.

INTRODUCTION

Mississippi Valley-type (MVT) Zn-Pb mineralization has long been known from Paleozoic host rocks in the Canadian Arctic Islands. It is the only type of mineral deposit demonstrated to be present in economic concentrations in the sedimentary rocks that form the bedrock of a vast area encompassing most of the Arctic Islands. Zinc-lead showings are present throughout a zone spanning Somerset, Bathurst, Cornwallis, and Devon islands, and form the Polaris camp, named for the Polaris lead-zinc mine currently operating on Little Cornwallis Island.

Reserves at the Polaris (Ordovician host rocks; operating since 1982) and Nanisivik (Mesoproterozoic host; operating since 1974) lead-zinc mines are almost depleted, and mine closures, projected to take place in the next few years, will terminate a source of economic activity in this region and erase a transportation and support infrastructure that has been vital to mineral exploration in the Arctic Islands. Although MVT deposits are generally found in clusters, and exploration in the Arctic has been conducted both throughout and beyond the area of the Polaris camp, no new economic deposit has been identified to date. It is therefore critical to Nunavut's long-term economic potential that zinc exploration in this area be promoted now, and that it be supported by scientific initiatives that help to refine and focus exploration strategies. Such an endeavour is also timely in a larger context, because Canada's base-metal reserves are progressively dwindling.

With the exception of research done at the Polaris Mine (e.g. Randell and Anderson, 1990; Randell, 1994), little is publicly known about the controls on mineralization throughout this zinc district. Some of the basic questions that remain unanswered include 1) whether the regional zinc belt developed from a single mid-Paleozoic fluid system or from multiple, unrelated systems of different ages; 2) whether all significant mineralization is predominantly structurally controlled or whether some occurrences are instead controlled by depositional facies architecture and have no significant structural component; 3) what are the critical attributes of structurally controlled mineralization; and 4) what are the timing and geological relationships between mineralization in the Polaris camp and showings in other parts of the Arctic Islands. These issues have a direct bearing on the validity and utility of exploration models. This three-year project is intended, therefore, to answer fundamental questions regarding the properties of, and controls on, zinc mineralization throughout the Paleozoic rocks of the Arctic Islands. The resultant geological model will then be publicly available as a framework for future exploration endeavours.

Field work in summer 2000 focused on reconnaissance mapping and sampling of selected known showings on eastern Cornwallis Island (Fig. 1). A crew of four to five individuals worked from a succession of four base camps (Fig. 2), over an interval of six weeks. Logistics were managed by the Polar Continental Shelf Project. Camps were moved by Twin Otter aircraft; access to the field sites was by all-terrain vehicle (ATV) and foot traverse. Field-derived results from summer 2000 will form the starting point for a proposed larger scale synthesis of the controls on mineralization of arctic Zn-Pb occurrences, including geochemical, petrographic, and geochronological analysis.

REGIONAL SETTING

Cornwallis Island is part of the Arctic Platform, located south of the structural front of the Parry Islands (Franklinian) Fold Belt and forming the northernmost extension of the Boothia Uplift. Strata here were only gently deformed by the

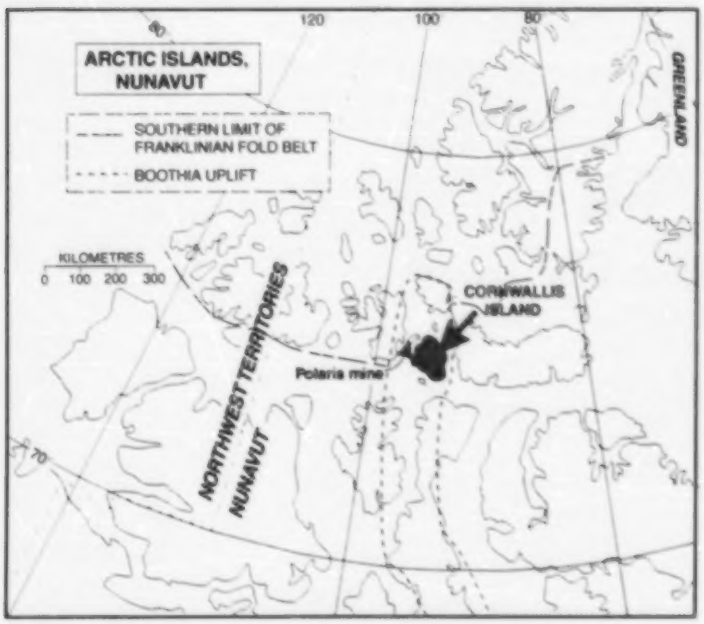


Figure 1.

Location of Cornwallis Island, Boothia Uplift, and southern limit of Franklinian Mobile Belt. (Geological boundaries after *Trettin, 1991a.)*

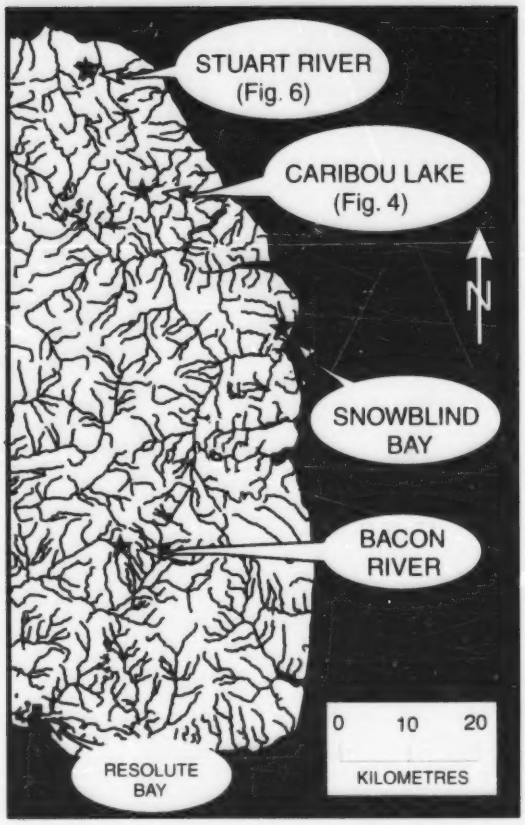


Figure 2. *Four areas investigated during summer 2000.*

Ellesmerian (Late Devonian–Early Carboniferous) Orogeny (Fig. 1; Thorsteinsson, 1986; Okulitch et al., 1991; Trettin et al., 1991a). Ordovician through Devonian carbonate and fine terrigenous clastic rocks are present at surface, with local Mesozoic outliers. Silurian to lower Devonian rocks in the east-central part of the island expose a lateral transition from platformal (south) to basinal (north) facies. The Boothia Uplift, a presumed basement-rooted horst, was active in Late Silurian to Early Devonian time and produced a profound angular unconformity separating Ordovician and Devonian rocks on the north end of the island that is important to certain types of Zn-Pb mineralization. The area thus consists of platformal carbonate rocks, either presumed (in the case of the Ordovician) or demonstrated (Silurian and Devonian) to have been deposited adjacent to basinal shale — a setting in which MVT deposits are classically developed (e.g. Anderson and McQueen, 1988; Sangster, 1996). The deposit at the Polaris mine is in such rocks; its mineralization is late Devonian (Christensen et al., 1995; Hall et al., 1998), making it contemporaneous with Ellesmerian orogenic events.

Eastern Cornwallis Island contains a number of zinc-lead mineral showings, in a range of Paleozoic host rocks (Fig. 3); many, but not all, of these showings can be readily identified from the air by their rusty weathering gossans. Topographic relief is subdued over a terrain that is low and poorly drained. Outcrop is extremely sparse and is generally found in drainages or as rare metre- to decametre-scale cliffs, many of which remain snow-covered throughout the summer. Mapping is therefore subtle, and based predominantly on rubble brought to the surface by permafrost processes. Inclement weather, snow cover, and ubiquitous muddy terrain that is inimical to foot or ATV travel present significant impediments to mapping and sampling in this area.

STRATIGRAPHIC UNITS RELEVANT TO MINERALIZATION

Five stratigraphic units contain Zn-Pb minerals on eastern Cornwallis Island (Fig. 3). All consist of carbonate facies that were amenable to mineralization owing to primary (depositional) porosity, secondary porosity (resulting from recrystallization or dolomitization), or fracture porosity, that permitted the invasion of mineralizing fluids, which in some cases further enhanced rock porosity by dissolution.

Thumb Mountain Formation (upper member)

The middle to upper Ordovician Thumb Mountain Formation has been divided into two informal members in the vicinity of the Polaris mine on Little Cornwallis Island (Randell, 1994). These members, and the marker units they contain, are also recognizable on eastern Cornwallis Island, although no continuous stratigraphic section of any significant thickness is exposed at surface. The lower member (about 260 m; Randell, 1994) consists predominantly of fenestral lime mudstone, locally with a restricted fauna of ostracodes, bivalves, and trilobites. The upper member (about 90 m) consists of variably dolomitized skeletal wackestone-floatstone, with several useful marker units. This upper member is the host unit to the bulk of the orebody at the Polaris mine, and the stratigraphic unit most commonly mineralized elsewhere in this district.

Cape Phillips Formation

The Ordovician–Silurian Cape Phillips Formation, present on the northern half of the island, consists predominantly of deep-water lime mudstone and shale, but contains a distinctive, basal, 10 m thick cliff-forming member (Fig. 3), similar to the upper member of the Thumb Mountain Formation, that is locally mineralized.

Allen Bay Formation

The uppermost Ordovician–lower Silurian Allen Bay Formation, present south of the facies front on south central Cornwallis Island, is laterally equivalent to the lower part of the Cape Phillips Formation. It consists of dolomitized skeletal wackestone-packstone-floatstone, and is mineralized in the vicinity of normal faults.

Barlow Inlet Formation

This upper Silurian–lower Devonian unit consists of platformal carbonate rocks ranging texturally from lime mudstone to skeletal wackestone-floatstone containing patch reefs variably composed of large stromatoporoids and corals. The formation is laterally contiguous and coeval with the upper part of the Cape Phillips Formation. Several different facies contain Zn mineralization.

Disappointment Bay Formation

This lower Devonian unit is the lowest formation above the profound unconformity separating Ordovician and Devonian strata on northern Cornwallis Island. Owing to poor exposure, little is known of its nature; all known facies are dolomitic. A basal polymictic cobble to boulder conglomerate up to 12 m thick is locally present; above this is a distinctive chert-chip conglomerate that also varies in thickness. Other facies noted in felsenmeer include a parallel-laminated doloarenite, wave-rippled doloarenite, and vuggy, massively bedded, finely crystalline dolostone. Only the basal conglomerate is involved in mineralization.

SHOWINGS ASSOCIATED WITH SIGNIFICANT TECTONIC STRUCTURES

Caribou Lake

Detailed mapping of a structurally complex, poorly exposed area surrounding three orange-weathering gossans in Ordovician rocks (Fig. 4) has refined the 1:250 000 scale map pattern of Thorsteinsson (1986) for a small area on northeastern Cornwallis Island; further investigation would reveal greater detail than that shown here. Gossans are located along normal faults, or at the junction of two normal faults. Brittle faulting in the area is common and expressed at surface by topographic lineaments, sparse exposures of fault breccia and gouge, and locally, where faults cut through argillaceous carbonate rocks of the upper Thumb Mountain and Irene Bay formations, by brick-red staining of mudrock and of burrow mottles in lime mudstone-wackestone. Strata between brittle faults are gently, but complexly, folded on a hectometric-kilometric scale. Mineralized rocks are those of the upper Thumb Mountain Formation; it is only where these strata are juxtaposed with certain faults that mineralization is developed.

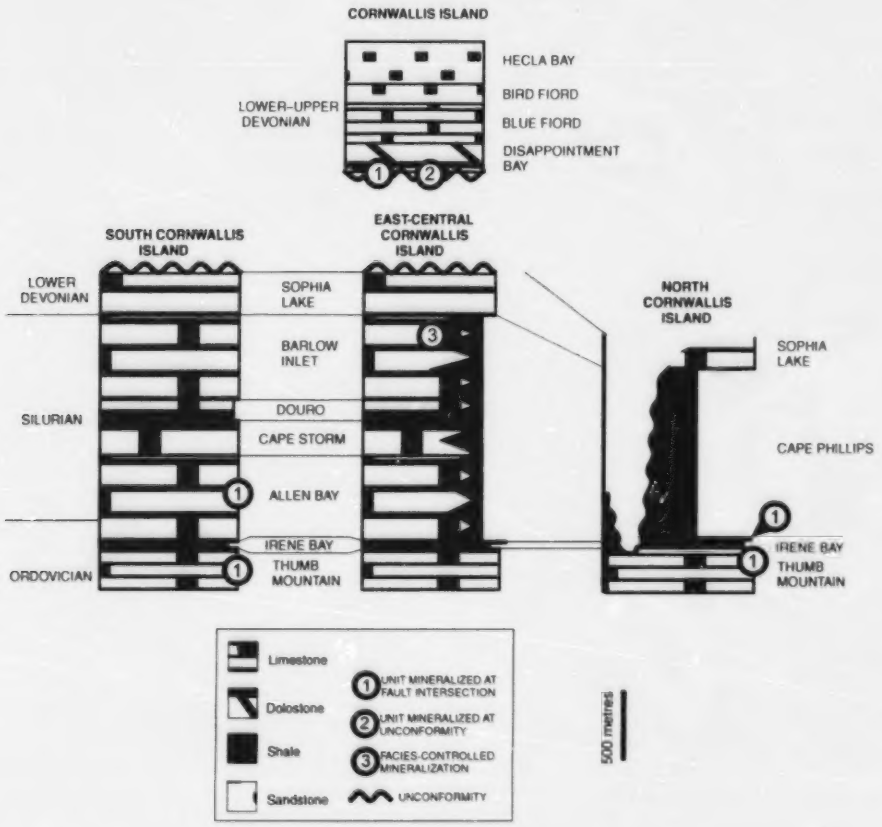


Figure 3. *Generalized stratigraphic columns* (modified from *Trettin, 1991b*) *for eastern Cornwallis Island, showing mineralized stratigraphic units.*

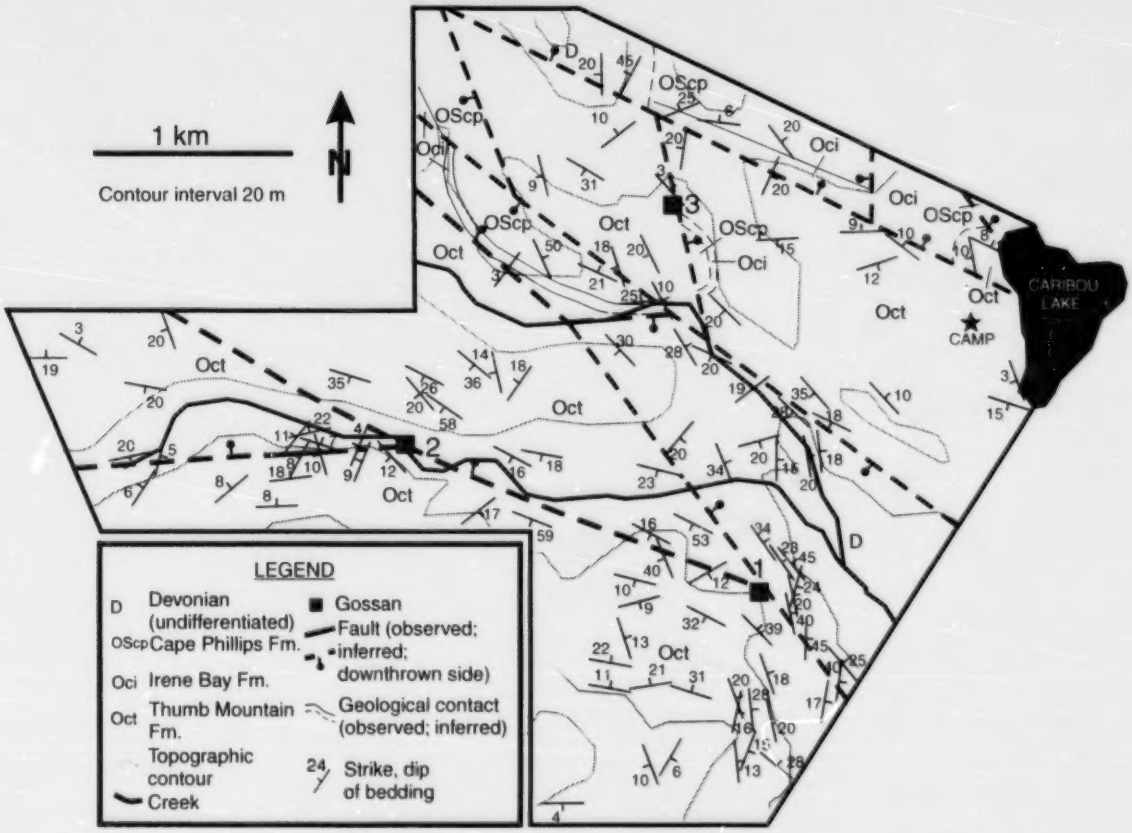


Figure 4. *Geological map of the area surrounding three gossans in the vicinity of Caribou Lake, Nunavut.*

Gossans #1 and #2 (Fig. 4) are located along an extensive, northwest-trending normal fault that is intersected by other faults. Gossan #1 is located where a north-northwest-trending fault truncates the northwest-trending fault. The gossan is approximately 150 m in diameter (east-west), bright orange, and conspicuous from the air; no in situ rocks are present within the gossan itself. Gossan #2 (Fig. 5a) is located where the same northwest-trending fault truncates a west-trending fault with minimal throw (a few metres), but extensive red discolouration. It is approximately 20 m wide and located on a steep slope bordering the northeast side of a small lake. No outcrop is present. Gossan #3, 5 m in diameter, is in a low area of little outcrop, but may be on a north-trending normal fault. Mineral textures for these localities have not yet been observed, owing to the deep weathering of the gossans.

Stuart River

Gossans (Fig. 6) are present in three distinct geological contexts: 1) along a west-southwest-trending normal fault that juxtaposes along its approximately 1 km length the nearly flat-lying basal cobble conglomerate of the Disappointment Bay Formation with gently east-dipping strata of the Cape Phillips Formation cliff member (eastern part of the fault), and the upper Thumb Mountain Formation (western part of the fault), both of which contain galena, marcasite, and zinc carbonate and oxide in partly filled vugs within several metres of the fault (Fig. 5b, c); 2) in the basal chert-chip conglomerate of the Disappointment Bay Formation (the cobble conglomerate is only locally present), where it is in unconformable contact with the upper Thumb Mountain Formation and possibly crosscut by an east-trending normal fault (the gossan is about 40 m by 12 m); and 3) over a strike-parallel length of about 400 m (encompassing several approximately 40 m by 10 m gossans) in upper Thumb Mountain strata adjacent to a northwest-trending fault.

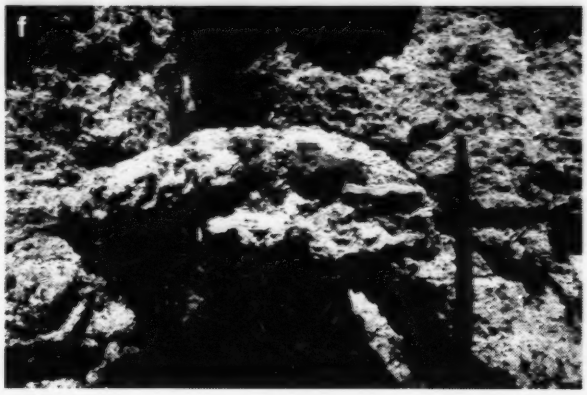
Bacon River

This area, bedevilled by an almost complete lack of outcrop or mappable rubble, exhibits extensive, rusty weathering gossans (Fig. 5d) up to 1.5 km long, along the 6 km length of a graben (*see* Thorsteinsson, 1986) that juxtaposes Silurian Allen Bay and Ordovician Bay Fiord through Thumb Mountain strata. Sphalerite and galena (Fig. 5e) are locally present even in these profoundly weathered gossans, commonly associated with bitumen.

a

e

b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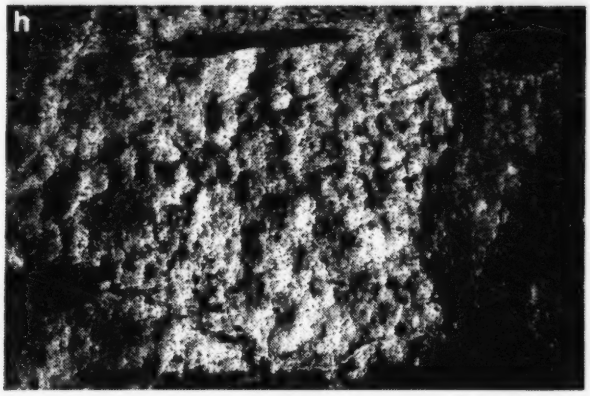
d


h

Opposite

Figure 5. *Zinc-lead mineralization from Cornwallis Island, Nunavut.* ***a)*** *Gossan #2 in upper Thumb Mountain Formation, Caribou Lake area. The gossan is the dark ground surrounding the snowpatch in the back- ground, on a steep slope above a small lake. View to northeast. See Figure 4 for location.* ***b)*** *Fault-associated mineralization, area 1, Stuart River. Vugs in the 'cliff-forming member' at the base of the Cape Phillips Formation are lined with dolomite, coarsely crystalline galena, and minor marcasite. See Figure 6 for location.* ***c)*** *Fault- associated mineralization, area 1, Stuart River. Vugs in basal conglomerate of the Disappointment Bay Formation are lined with dolomite, which is successively overlain by galena crystals and patches of marcasite.* ***d)*** *Typical fault-related gossan (dark area to the left), Bacon River area. All terrain vehicle and seated person provide scale.* ***e)*** *Typical mineralization from deeply weathered gossans in the Bacon River area. Sphalerite is red-weathering and roughly round in cross-section; the larger, irregular dark areas are galena.* ***f)*** *Sphalerite (dark brown nodules in centre) from perireefal strata of the Barlow Inlet Formation, Snowblind Bay area.* ***g)*** *Prominent joint surfaces on which sphalerite crystals are found. Dolomudstone facies of Barlow Inlet Formation, near Snowblind Bay. The person provides scale.* ***h)*** *Sphalerite from joint surfaces in the Barlow Inlet Formation. Dark red crystals several millimetres in diameter protrude from the surface of the joint. The pencil is 14 cm long.*

SHOWINGS WITH NO SIGNIFICANT STRUCTURAL CONTROL

Snowblind Bay

Sphalerite is present in upper Silurian–lower Devonian carbonate rocks of the platformal Barlow Inlet Formation within 2 to 3 km of the laterally contiguous facies change to deeper water shale and lime mudstone of the Cape Phillips Formation. Its distribution is conspicuously different from that of iron-stained rocks in the same formation. Sphalerite showings contain no galena and comparatively little iron sulphide or coarsely crystalline dolomite. Two host facies are involved. Vuggy, dolomitized perireefal crinoid wackestone-floatstone contains sphalerite in centimetric pores formed within intact strata, or in local decimetric areas of dissolution-collapse pseudobreccia, focused along 50 m of a distinct stratigraphic horizon. Framboidal masses of dark brown sphalerite project inward from the margins of the vugs, locally filling them completely with fibrous masses that radiate from one or several nucleation points (Fig. 5h). Sphalerite is also present on and around both present-day (northwest- and north-northwest-trending) and ancient healed fracture surfaces within dolomitized lime mudstone in the same succession. Sphalerite in these showings consists of isolated, millimetric, red-brown euhedra on joint surfaces, discs of radial fibres that are confined in their short dimension by the limits of the healed fractures, and fillings of vermiform pores in the dolomudstone immediately adjacent to joints. These present-day north-northeast-trending joints were clearly fractures that developed initially prior to

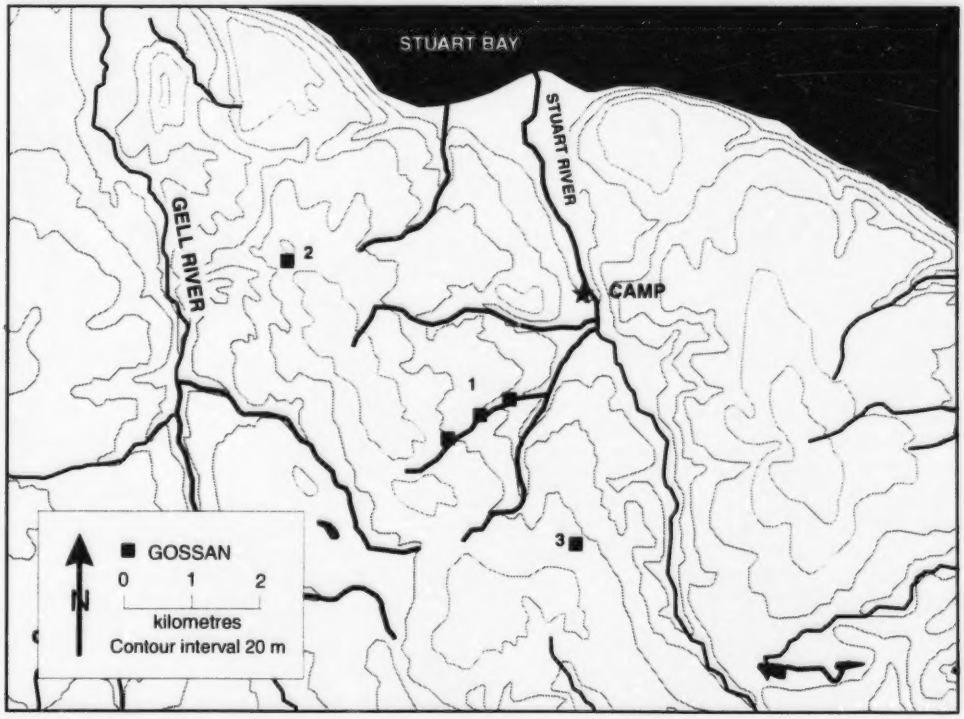


Figure 6. *Location of gossans in the vicinity of Stuart River, northern Cornwallis Island, Nunavut. See text for descriptions.*

precipitation of the sphalerite. Little coarsely crystalline dolomite is present in either setting, and large-scale solution-collapse pseudobreccia is absent. There is no obvious structural control in this area, although the showings are distributed very roughly along a 1.5 km long, north-northeast trend (between a river valley 4 km north of and a small lake 1.5 km northwest of Snowblind Bay) that is oblique to strike, and might be the expression of a subtle structural feature. The showings have no features (such as brightly coloured weathering products) that would allow them to be identified from a distance.

SUMMARY

Zinc-lead showings on eastern Cornwallis Island are present in three general geological settings: 1) in structurally controlled gossans in Ordovician through Devonian rocks, where postfolding normal faults cut across permeable strata of upper Thumb Mountain, lowermost Cape Phillips, Allen Bay, and lowermost Disappointment Bay formations; 2) in apparently facies-controlled, nongossanous showings in Silurian–Devonian perireefal carbonate rocks of the Barlow Inlet Formation, near the transition from platformal (Barlow Inlet) to basinal (Cape Phillips) facies; and 3) along the unconformable contact of the upper Thumb Mountain Formation and the basal Disappointment Bay Formation. These results suggest 1) that significant mineralization could be present in stratigraphic units other than the Thumb Mountain Formation and 2) that facies boundaries, the Silurian–Devonian unconformity, and faults all contribute to the development of mineral showings on eastern Cornwallis Island. The complete lack of galena and dearth iron-sulphide minerals in showings at Snowblind Bay suggests that the fluid responsible for these showings had a different composition from that of the fluids that formed the showings at Caribou Lake, Stuart River, and Bacon River, and might have belonged to a different mineralization event altogether.

Field work planned for 2001 will focus on mapping and detailing the geological context and history of representative showings on Bathurst, Devon, and Somerset islands, and on collecting material for petrographic work, geochemical analysis, and dating. Special emphasis will be placed on unravelling the relative timing and movement of the many faults that make this area structurally complex. Work to follow will address the paragenesis of mineral showings, geochemical and isotopic characteristics of the mineralization, its parent fluids, and the rocks hosting the sulphides. Results from within the Polaris district will then be compared with those from samples, already in hand, from other areas in the Arctic Islands, to determine whether they all belong to the same fluid system and mineralizing event, or whether exploration philosophies should include the possibility of multiple independent mineralization events in a variety of geological contexts. It is hoped that the final product resulting from this project will be a model that fully describes the geological conditions behind mineralization in this region, which will permit explorationists to focus on areas where these conditions are most likely to be met.

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